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UNITED STATES
DEPARTMENT OF THE INTERIOR
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BUREAU OF MINES
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INFORMATION CIRCULAR

# COST OF MINING 55 TONS OF COPPER-NICKEL ORE AT THE GREAT EASTERN PROSPECT, BUNKERVILLE, CLARK COUNTY, NEV.

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# COST OF MINING 55 TONS OF COPPER-NICKEL ORE AT THE GREAT EASTERN PROSPECT, BUNKERVILLE, CLARK COUNTY, NEV.[1]

By Paul T. Allsman[2]

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## INTRODUCTION

This paper gives the cost and describes the mining of 55 tons of nickel-bearing rock by hand methods from a prospect in southern Nevada, June 15, 1937, by the Mining Division of the Bureau of Mines. The geology, mineralogy, and problems related to future development also are discussed briefly. The main object was to obtain a 55-ton sample within the limited period during which funds were available; little time was available to make a first-hand detailed study of the possibility of commercial ore deposits being found. The sample was desired by the Metallurgical Division of the Bureau for experimental purposes at the Electro-Metallurgical Station at Boulder City, Nev. The term "ore" is used loosely in the following discussion to designate dike material containing nickel and copper, without consideration of its commercial value.

## ACKNOWLEDGMENTS

Material concerning the geology and mineralogy of the prospect and district was obtained from Geological Survey publications by Bancroft[3] and Longwell[4].

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7029."

[2] Associate mining engineer, Mining Division, Bureau of Mines.

[3] Bancroft, Howland, Platinum in Southeastern Nevada: Geol. Survey Bull. 430, Contributions to Economic Geology, Part 1, 1910, pp. 192-199.

[4] Longwell, Chester R., Geology of the Muddy Mountains, Nev.: Geol. Survey Bull. 798, 1928.

## GEOGRAPHY

The Great Eastern mine is in the Copper King mining district. The only other prospect of any importance in the district is the Key West, about 1 mile southwest of the Great Eastern. They are in the foothills on the southwest side of the Virgin Mountains in Clark County, Nev., and are reached by 13 miles of winding, steep, dirt road from paved highway U. S. 91; the road leaves the highway 5 miles from Bunkerville and 77 miles from Las Vegas.

The average altitude of the flood plain at the Virgin River nearest the district is about 1,000 feet. The Key West and Great Eastern are east at altitudes of about 3,660 and 4,175 feet, respectively. About 4 miles east of the mines, Virgin Peak rises to an elevation of about 7,500 feet.

The climate of the region exhibits daily and seasonal variations characteristic of the arid Southwest. A supply of pure water sufficient for domestic demands flows from two adits of the Great Eastern; old timers state that the flow has been continuous since the work was done.

## GEOLOGY

In 1909, Bancroft[5] visited the Great Eastern and Key West properties and described the geology briefly. The underlying rock in the vicinity is a pinkish coarse-grained gneiss of granitic composition showing distinct gneissic structure, having orthoclase feldspar and quartz in about equal amounts, with a little hornblende. Overlying this is a limestone conglomerate a few feet thick composed of rather small fragments. Above this is a pinkish limestone of considerable thickness, which assumes a yellow color on weathering. This formation extends to a point within 2 miles of the Key West, where it has been entirely eroded and the underlying gneiss exposed. About 2 miles east of the Key West and Great Eastern the limestone reappears and is apparently of great thickness. Thus, a narrow strip approximately 4 miles wide of probably pre-Cambrian rocks has been exposed. This strip contains the Key West, Great Eastern, and many evidences of extensive prospecting.

The prevalent direction of schistosity seems to be northeast with an almost vertical dip. The rocks, standing almost vertical, with accompanying jointing parallel to the shearing planes, form ridges in places. Along these ridges are intruded various basic rocks, with aplite and pegmatite, all of which are common to the vicinity. The two latter intrusions are evidently later than the metamorphism of the region.

Dikes of extremely basic composition are the most interesting feature of the geology of the area as some of them represent the ore-bearing formation. The basic dikes resemble each other in general appearance. The barren dikes, however, can be distinguished readily from the mineralized dikes by the presence of comparatively large quantities of feldspar. The mineralized dikes are intruded into the gneisses in a number of places with no apparent regularity except in direction of strike. One of the dikes between the Great Eastern and Key West has been traced for over 1,500 feet on the surface, and is shown to be from 50 to 100 feet wide in places; its ore-bearing possibilities have not been determined. Usually, surface exposures are 100 feet or more in length and vary in width from 10 to 50 feet. They are commonly faulted both horizontally and vertically, although, apparently, in places they terminate by pinching out, forming lenses.

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[5] Work cited, footnote 3.

The Great Eastern dike, from which the 55-ton sample was mined, is a very basic intrusion having the composition of peridotite; it is typical of the mineralized dikes. The rock is microscopically holo-crystalline; the chief minerals are augite, olivine, biotite, and enstatite, in order of relative abundance. This would constitute an enstatite-mica picrite, a variety of peridotite. The rock also contains pyrrhotite, magnetite, and chalcopyrite, which apparently are of primary origin and are intimately intergrown. These minerals constitute a varying relative proportion of the whole dike, being quite prominent in the ore mined, with pyrrhotite predominating. Chromite has been recognized. The economic metals that have been found in various samples analyzed over a number of years comprise nickel, copper, metals of the platinum group, and occasionally a small amount of cobalt and, rarely, gold and silver.

The Great Eastern dike, as disclosed in the stope from which the 55 tons of ore was taken, had a strike of about N. 60° E. and a steep dip to the southeast, as indicated by a small area of footwall that was exposed. An adit entering the ore shoot passed through a fault, cutting the dike almost at right angles and dipping about vertical. About 12 to 18 inches of gouge was contained in the fault fissure. The hanging wall was not reached in stoping, although the dike was penetrated about 13-1/2 feet.

The ore encountered was hard and extremely difficult to drill by hand; it runs about 10-1/4 cubic feet per ton of solid rock. The wall rocks are softer than the ore; the contact between ore and waste, as shown in the footwall, is well defined. Sulphides appear to be evenly distributed across the full width of the dike exposed in the stope.

## GENERAL

A few carloads of ore have been shipped from the Key West and a small tonnage has been milled on the ground. This mine has been developed on three levels. The mineralized dike on the Great Eastern has been developed only sufficiently to show the presence of ore. Other dikes rarely have been prospected below a possible leached zone at the surface. Deeper prospecting, probably with diamond drills, to determine grade of ore, extent, and relation to faulting, appears to be a logical approach for further prospecting. The future of the district depends upon the results of further development.

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At present, the most economical method of treatment of the ore appears to be concentration of sulphides at the mine and final recovery of the metals at some place on Mead lake.

A large amount of cheap power is available at Boulder Dam that could be used for a pyrometallurgical process for treating the concentrate. Eventually the lake will be within less than 10 miles of the district. Concentrates could be hauled to the lake and barged to Boulder Dam or some other possible industrial center on the lake shore for final recovery of the metals.

It is doubtful whether the mines would develop sufficient water for milling purposes, and this probably would have to be augmented by pumping from the Virgin River, a distance of less than 10 miles horizontally and 2,500 feet vertically.

## DEVELOPMENT

Development on the Great Eastern dike comprises a lower and an upper adit. The lower adit was driven southeast about 100 feet, where it branched; the right branch cut the dike to the southwest at a flat angle and the left branch was driven east toward the dike. The upper adit was started at an elevation of about 90 feet above the portal of the lower and 700 feet northeast; it was driven south about 50 feet, then continued in a general northeast direction in search of the dike. Good ore was encountered at about 300 feet from the portal; the 55-ton nickel sample was taken from this oreshoot.

The Key West (1909) had been prospected by over 3,000 feet of development work, comprising two shafts (the main one 312 feet deep), three levels, winzes, and drifts. The prospect remained idle until 1936, when some additional work was done. The results of this last work have not been made public.

Minor prospecting in the district comprises a number of shallow pits and short tunnels between and in the vicinity of the Great Eastern and Key West. These have exposed extensive dikes similar to those of the two prospects.

## MINING

Considerable preliminary work was necessary before actual mining and tramming could start, although a small amount of ore was broken in the face and shoveled back during the first few days.

### Preliminary Work

A miner and two muckers were employed at Mesquite to start the work. A half day was required to assemble camp equipment, drill steel, powder, and various other tools and to truck them to the mine. While a camp was being established on the mine dump, one of the men cleared away a large pile of waste that was blocking the adit mouth to allow a 3-foot accumulation of water to drain out.

Preliminary work at the mine included clearing the waste and water from the upper adit, salvaging track, ties, bolts, and spikes from the lower adit, relaying the track in the upper adit, and clearing off the upper dump for an ore-storage site. From 35 to 40 cars of waste was removed from the upper adit as fast as the track was advanced in order to make room for the track and to provide drainage. About 450 feet of track was salvaged from the lower adit and carried by hand about 700 feet to the upper adit. The rails, bolts, and spikes were badly corroded, and over half of the ties were too rotten to be used again. About 375 feet of track was found to be sound enough for temporary use. Sufficient scrap wood and small timber was gathered over an area of several square miles to replace the rotten ties. Bolts and spikes were salvaged from various sources.

The total 375 feet of track and the work connected with it were completed by two men in 5 days. The author stayed at the mine and assisted with the work during the entire period.

Considerable time was consumed and difficulty was encountered in obtaining an ore car. A 15-cubic foot car in good condition was borrowed from one of the co-partners in the ownership of the mine. This was hauled over poor roads for about 10 miles to a position about 200 feet below the portal of the tunnel. Four men were required to push the car uphill through brush and rock to the mine dump.

## Stoping

Mineralized sections of the ore-bearing dikes had been sampled previously by the Bureau of Mines. The best exposure of ore was in the face of the upper adit; ore had been penetrated 4 to 5 feet. The cross-section of the adit at the end was 4 by 6 feet. Although it was difficult to drill the ore by hand, the tonnage to be mined did not justify the expense of installing an air-compressor.

The actual work of stoping was started by a miner immediately as the face became accessible. During the first 5 days, the miner had broken about 15 cars of ore; this work opened the face sufficiently to accommodate two miners. One of the muckers, who had had previous experience as a hand driller was started as a helper when the preliminary work was finished; the other mucker loaded and trammed the ore to the dump, handled steel, and did other miscellaneous work. When not otherwise occupied, his time was spent in drilling when the stope was opened sufficiently to accommodate a third miner.

The usual routine of mining consisted of picking down, shoveling back, drilling, and blasting. Loading and tramming was conducted simultaneously with mining. Normally, a 10-hour shift was worked.

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At first, plans were to pick down and shovel back at night, several hours after blasting. This was found to be impracticable, as lack of ventilation prevented the gas from being cleared out in that time. It became necessary to pick down at the beginning of the day shift, when the air was practically free of gas.

Drilling was done by hand and, except experimentally, all was by single-jacking. Double-jacking was tried, but it soon became apparent that less hole was being drilled per man. Holes were not drilled in any regular pattern; every advantage was taken of slips in slabbing off the ore. Holes were placed in soft spots, depressions, and bootlegs after making certain they were free of powder. Drilling in the hard rock caused the drills to lose gage rapidly, making it rarely possible to drill deeper than 18 inches. The limit was 12 or 13 inches in many holes. Steel was mostly old and of poor quality. It was obtained from several sources and ranged from 1/2 to 7/8 inch in diameter. Some pieces of steel were badly water checked or had been improperly heat-treated; other pieces were made from hollow hexagonal steel, making it difficult to forge a good cutting edge.

Usually, about eight holes were blasted each shift, using 40-percent gelatin dynamite, no. 6 caps, and fuse with a 5-foot minimum length. Shots were fired in rotation, according to the judgment of the miner. Three misfires occurred during the mining period.

At the end of the period, the maximum dimensions of the stope were about 13-1/2 feet across the width of the dike, 9 feet along its strike, and 8-1/2 feet high. The amount of pyrrhotite increased as mining progressed. The ore was softer on the footwall side, probably due to a slight seepage of water along the footwall and fault. The core of the dike was uniformly hard; however, it broke well to extensive slips, usually leaving a good back and walls.

Considerable difficulty was encountered in tramming, due to the crookedness of the adit and the poor condition of the track, particularly the rotten ties.

A few dangerous places developed in the adit by loosening of the gneiss. Some time was lost searching for timber suitable for stulls to support these bad spots.

Originally, the plans were to have steel sharpened at Mesquite, about 23 miles from the mine; after one batch of steel had been handled in this manner, the plan was found to be impracticable and was abandoned. The ore proved harder than was supposed at first, and the plan would require the full-time service of a blacksmith to sharpen steel and of a car and driver to haul it.

After the fourth day, Robert Baker, a partner in the ownership of the property, arrived at the mine and spent his time sharpening steel in an old blacksmith shop at the portal of the lower adit. The arrangement worked satisfactorily until the work was completed.

The miner and blacksmith were partners in the contract and furnished board. Cooking was done by the men.

## PERFORMANCE

The following table gives the chief items of performance:

| | |
|---|---|
| Tons of ore mined | 55 |
| Cars of waste cleaned up | 40 |
| Length of period, days | 18 |
| Hours worked per shift | 10 |
| Total man-shifts | 86 |
| Ton of ore per man-shift | 0.64 |
| Track salvaged, feet | 450 |
| Track relayed, feet | 375 |
| Time salvaging and relaying track, man-shifts. | 10 |
| Total footage drilled (estimate) | 115 |
| Feet drilled per miner-shift | 3.2 |
| Pieces of steel sharpened (estimate) | 900 |
| Inches drilled per piece sharpened | 1.5 |
| Explosives consumed, 40-percent gelatin, pounds | 62.5 |
| Pounds explosives per ton of ore | 1.13 |

## COSTS

The following table gives the distribution and estimated cost of labor:

### Distribution of labor

| Item | Shifts per day | Total shifts | Rate per shift, 10 hours | Total |
|---|---|---|---|---|
| Mining: | | | | |
| Miner | 1 | 18 | [1] $5 | $90 |
| Helper | 1 | 18 | [1] 4 | 72 |
| Shoveling and tramming | .445 | 8 | [1] 4 | 32 |
| Track laying | .555 | 10 | [1] 4 | 40 |
| Steel sharpening | .779 | 14 | 5 | 70 |
| Supervision[2] | 1 | 18 | 6 | 108 |
| Total | 4.779 | 86 | | 412 |

[1] Includes board [2] Not included in the allotment for mining.

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The following table contains costs of mining 55 tons of ore for the period June 15 to 30, 1937:

Cost per ton of ore mined

| | Total cost | | Cost per ton | |
|---|---|---|---|---|
| Supervision[1] | $108.00 | $108.00 | 1.97 | 1.97 |
| Labor:[2] | | | | |
| Mining | 162.00 | | 2.95 | |
| Shoveling and tramming | 32.00 | | .58 | |
| Steel sharpening | 70.00 | | 1.27 | |
| Track laying[3] | 40.00 | 304.00 | .73 | 5.53 |
| Supplies: | | | | |
| Explosives | 10.50 | | .190 | |
| Caps and fuse | 5.50 | | .100 | |
| Carbide | 3.00 | | .055 | |
| Fuel[4] | 2.00 | 21.00 | .035 | .38 |
| Miscellaneous[5] | 75.00 | 75.00 | 1.36 | 1.36 |
| Total | | 508.00 | | 9.24 |

[1] Furnished by Mining Division, Bureau of Mines.

[2] Includes board.

[3] Includes reclaiming track and cleaning tunnel.

[4] Blacksmith coal.

[5] Rental of equipment and incidentals.